

STRAY CURRENT PROTECTION

E1. SCOPE

E1.1 Intent. This appendix provides the requirements for preventing underwater body corrosion due to stray current flow from improperly connected electric arc welding equipment.

E2. BACKGROUND

E2.1 Underwater corrosion. Underwater hull and shaft corrosion is, in large part, directly attributable to improper hookup of welding leads while work is being performed on ships which are waterborne. Corrosion resulting from improper weld lead hookup is induced through electrolytic action by stray electrical currents.

E2.2 Current Flow. Current flow is caused by the difference in electrical potential between any two localities. Even though the path through water offers greater resistance to current flow than adjoining electric ground cable, water still will carry a fraction of the current and create an undesirable condition.

E3. REQUIREMENTS

E3.1 Welding equipment. To prevent possible serious damage to electronic, electrical, mechanical, and ordnance equipment, as well as pitting of ship structure, while electric arc welding on ships, both waterborne and in dry or floating docks, observe the following requirements:

E3.1.1 Each ship shall have a separate welding current power source.

E3.1.2 The return current cable of any welding generator shall never be grounded to anything other than the ship the cable is servicing.

E3.1.3 The welding cable used in each welding circuit, both in the electrode and in the ground or return side of the circuit, shall be completely insulated, and not permitted to drop overboard into the water.

E3.1.4 The frame or case of the welding machine, except engine-driven types, shall be grounded, except portable and mobile engine-driven types complying with NFPA 70 need not be so. Frames shall be grounded to the hull if shipboard and to earth ground if the welding machine is located ashore.

E3.2 Connections. Cables and lugs used for electric arc welding shall meet the following requirements:

E3.2.1 Return conductor size. The cross-sectional areas of the return current cable should be one million circular mils minimum for each 1,000 A for each 100 feet. One or more cables, connected in parallel, may be used to meet the minimum cross-sectional area requirements. Such paralleled cables must connect to the same bus or waterway bar at each end. A nomograph showing required cable size for return current leads is presented in [Figure E-1](#).

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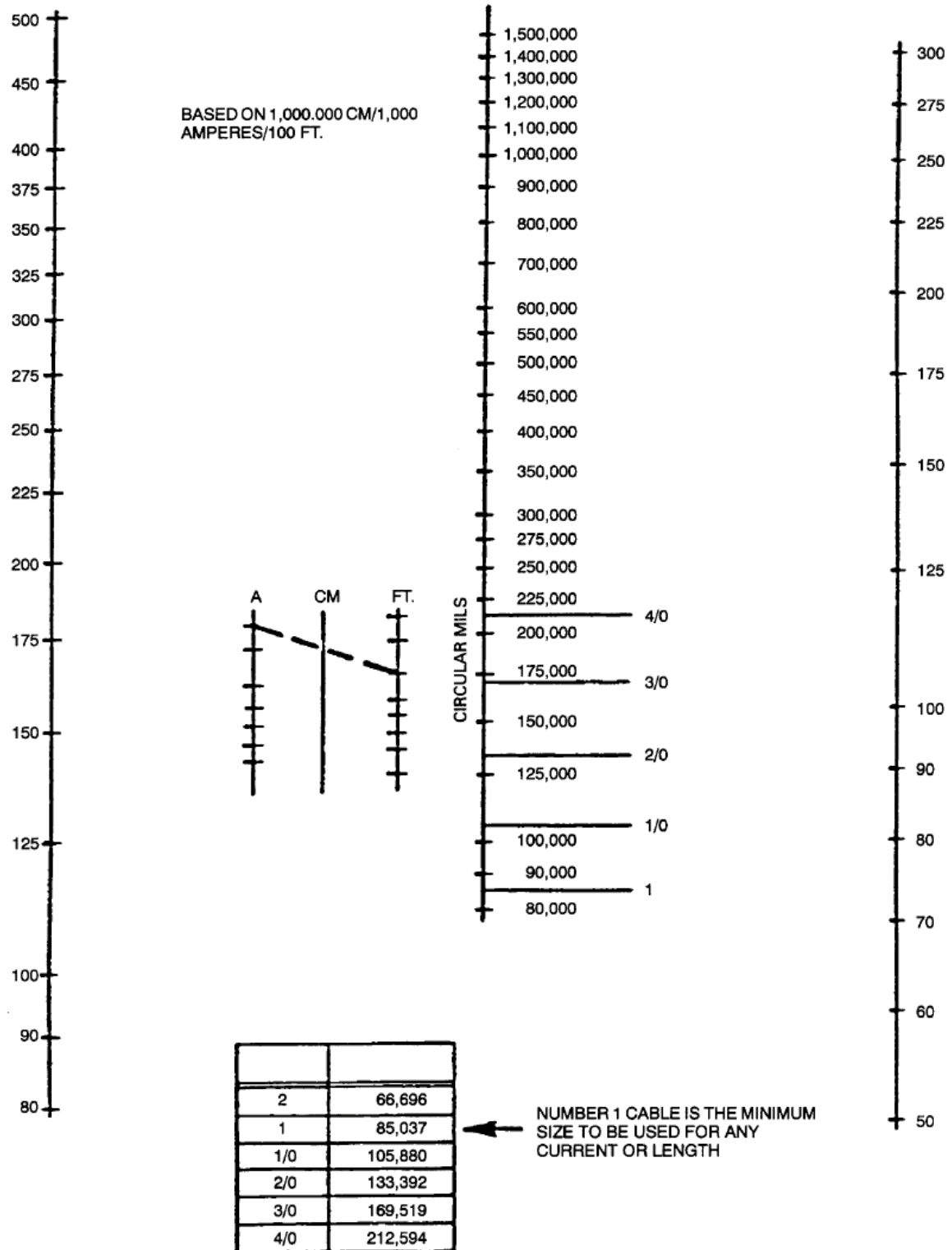


Figure E-1. Nomograph for Copper Return Current Conductor Size

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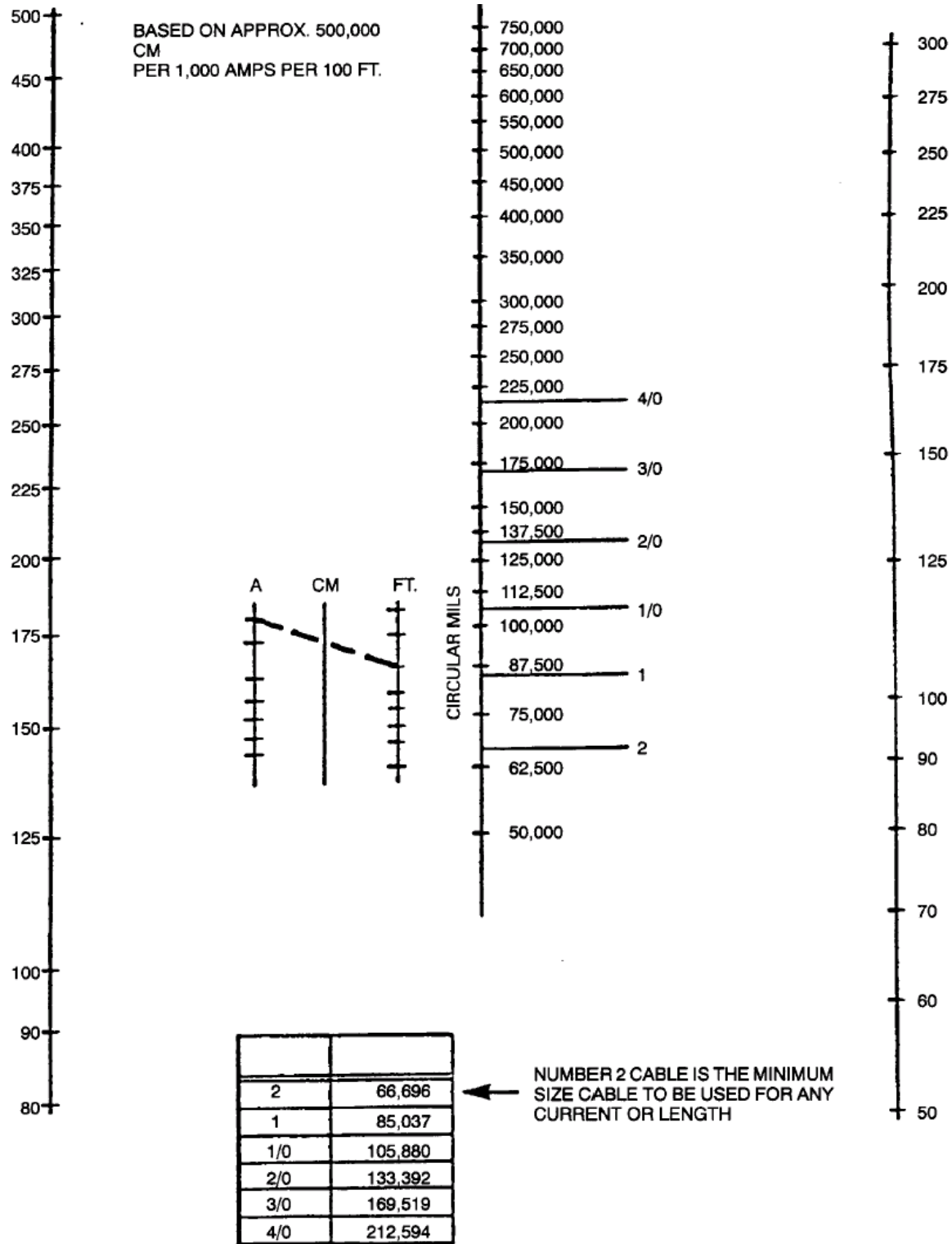


Figure E-2. Nomograph for Copper Electrode Lead Conductor Size

E3.2.2 Electrode conductor size. Manufacturers' recommendations for electrode lead cable size shall be used. Lead cable size is approximately 500,000 circular mils for each 1,000 A for each 100 feet. A nomograph showing copper electrode lead conductor size is presented in [Figure E-2](#).

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E3.2.3 Cable lugs. Return current cable lugs shall be secured tightly to grounding plates. The lug contact area shall be cleaned thoroughly to base metal. Ensure the adequacy of each return current cable connection between the ship's hull and power source by checking the resistance initially and after every setup change before welding. The maximum permissible resistance shall be 125 microhms ($\mu\Omega$) for each connection, or the voltage drop across the connection shall be a maximum of 25 millivolts (mV) for a current of 200 A. Use Ohm's law ($V = IR$) to determine the allowable voltage drop for currents other than 200 A.

E3.2.4 Insulation resistance. The insulation resistance between the welding return current cable and the welding machine case shall not be less than 0.1 megohm ($M\Omega$) when the machine is not connected to the ship. Resistance less than 0.1 $M\Omega$ indicates improper insulation of the return current cable or a need to clean the welding machine. Perform insulation resistance checks during initial connection and after every setup change before welding.

E3.3 Welding unit arrangements. Combinations of electric arc welding unit arrangements with correct and incorrect return current connections are shown in [Figure E-3](#), [Figure E-4](#), [Figure E-5](#), [Figure E-6](#) and [Figure E-7](#). These figures represent common arrangements and errors in making welding machine connections. Details for making provisions for welding return current connections on steel surface ships are shown in [Figure E-8](#).

E3.4 Special precautions. Observe the special precautions below when welding on or near electronic, electrical, mechanical, navigational, or ordnance equipment:

E3.4.1 Magnetic compass. When welding in or near the pilothouse or other locations with a magnetic compass, maximize the separation between the binnacle and all arc welding leads. Where leads must approach within 10 feet of the binnacle, notify the COR so that Ship's Force may remove the compass prior to welding.

E3.4.2 Sensitive electronics. Precautionary measures outlined in manufacturers' equipment manuals and other documents should be observed when welding on or near sensitive electronic equipment. Control cables often must be disconnected and sensitive modules removed from platforms equipped with electronic engine control systems.

E3.4.3 Welding return current. The static grounding straps on electronics enclosures, electrical equipment, machinery, and ordnance equipment have not been designed, and shall not be used, as welding current returns. Welding current shall not be allowed to pass through bolted access covers or soft patches, gear meshes, bearings (ball, roller, or bushing type on components such as crane turrets, winches, capstans, windlasses, gun mounts, motors, and shafting), nor hinge pins (doors, hatches, and scuttles), to return to ground.

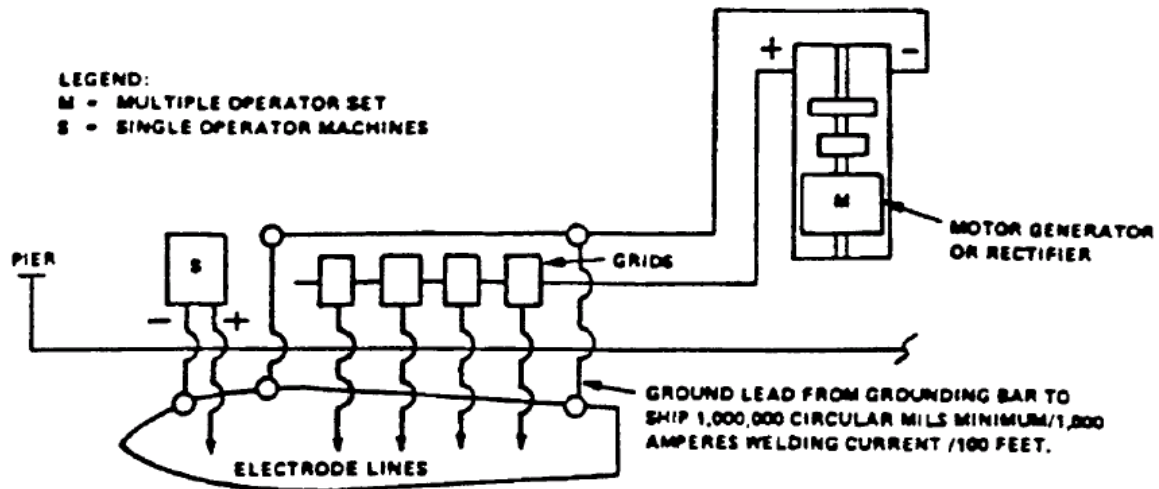
E3.4.4 Location of return current cables. When practicable, the welding return current cable connection shall be no farther than 10 feet from the work. This ensures that welding current does not flow through bearings, threaded joints, and other areas where arcing could occur.

E3.4.4.1 Mechanical. When systems such as piping, pressure vessels, or machinery are being welded, a single return current cable connection should be located as close to the work as possible.

E3.4.4.2 Ordnance. When welding on piping that leads into loaded ordnance equipment areas, the return current cables shall be split into two equal conductors so that one run is connected to the pipe on each side of the welding area, and located as close to the area as possible. If pipe hangers or branch pipes are located between the dual return current connections, provide additional split return current connections to

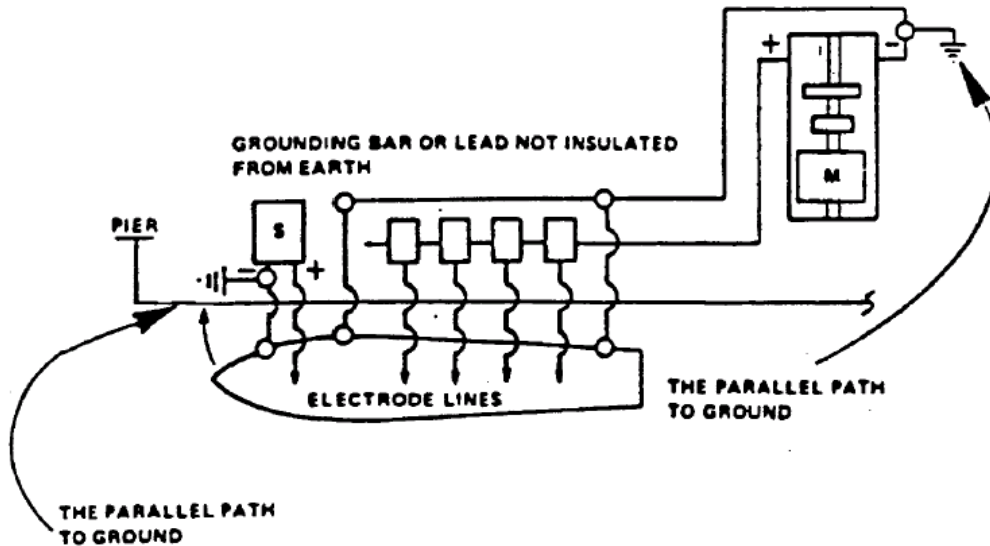
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such items.



NOTE: GROUNDING BAR OR LEAD SHALL BE INSULATED FROM EARTH AND OTHER STRUCTURES, BE OF SUFFICIENT CROSS-SECTIONAL AREA TO CARRY THE WELDING CURRENT, AND SHOULD REMAIN ABOVE WATER WITH TIDE CHANGES OR SHIP MOVEMENTS.

CORRECT

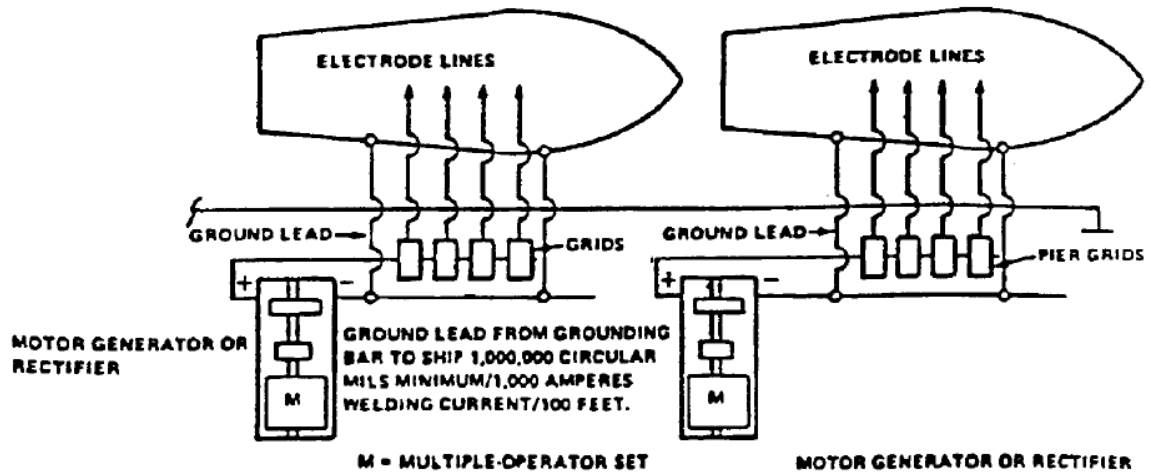


NOTE: WITH NEGATIVE SIDE OF GENERATOR OR RECTIFIER GROUNDED, PART OF THE WELDING CURRENT FLOWS FROM THE SHIP'S HULL TO THE WATER AND EVENTUALLY REACHES THE NEGATIVE SIDE OF THE GENERATOR OR RECTIFIER.

INCORRECT

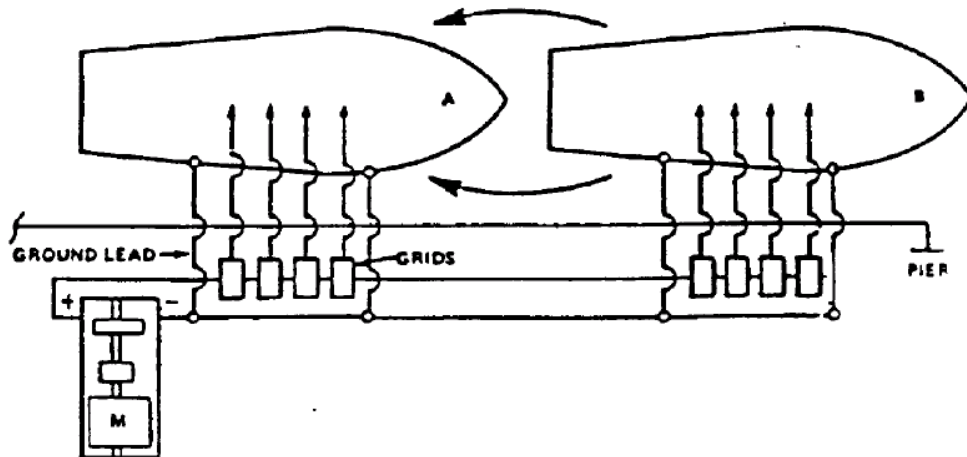
Figure E-3. Hookup for Single Ship at Pier

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NOTE: WELDING ON TWO OR MORE SHIPS (IN CASE OF MULTIPLE-OPERATOR MACHINE) SHOULD NOT BE PERFORMED WITH THE SAME GENERATOR OR RECTIFIER.

CORRECT



NOTE: WHEN TWO SHIPS ARE CONNECTED TO THE SAME GENERATOR OR RECTIFIER, THE RESISTANCE OF THE NEGATIVE RETURN BETWEEN THE SHIPS CANNOT BE MADE LOW IN COMPARISON WITH THE RESISTANCE THROUGH THE WATER. SOME OF THE CURRENT USED ON SHIP B FLOWS THROUGH THE WATER, CORRODING METAL OFF SHIP B AND POSSIBLY BLISTERING PAINT ON SHIP A.

INCORRECT

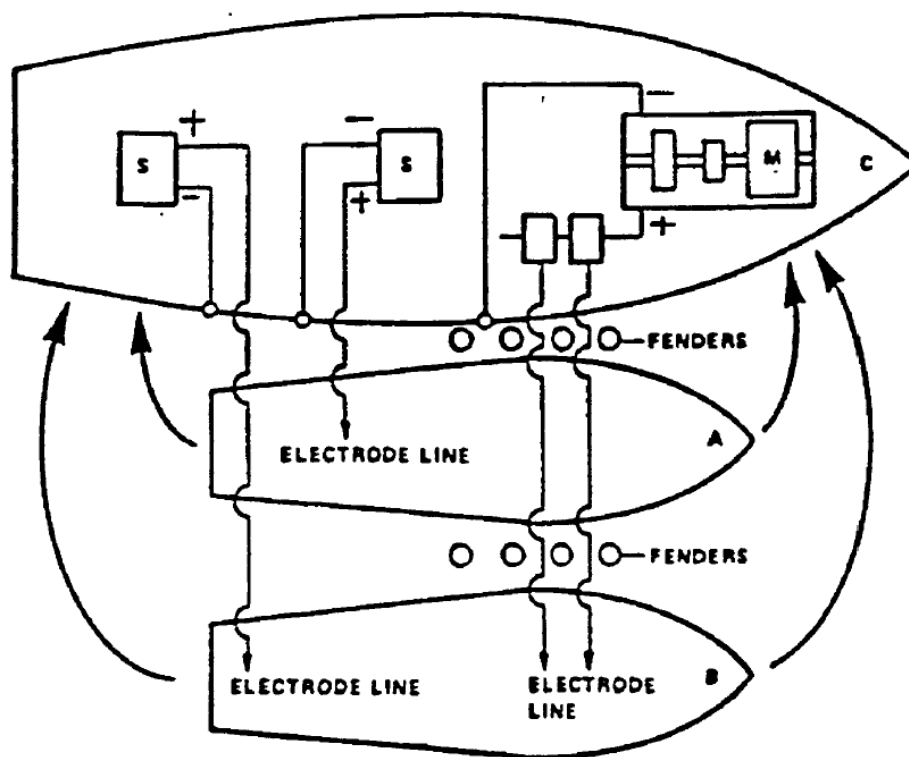
Figure E-4. Hookup for Two Ships at Pier

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- CORRECT**

Figure E-5. Hookup for Ships Afloat (Sheet 1 of 2)

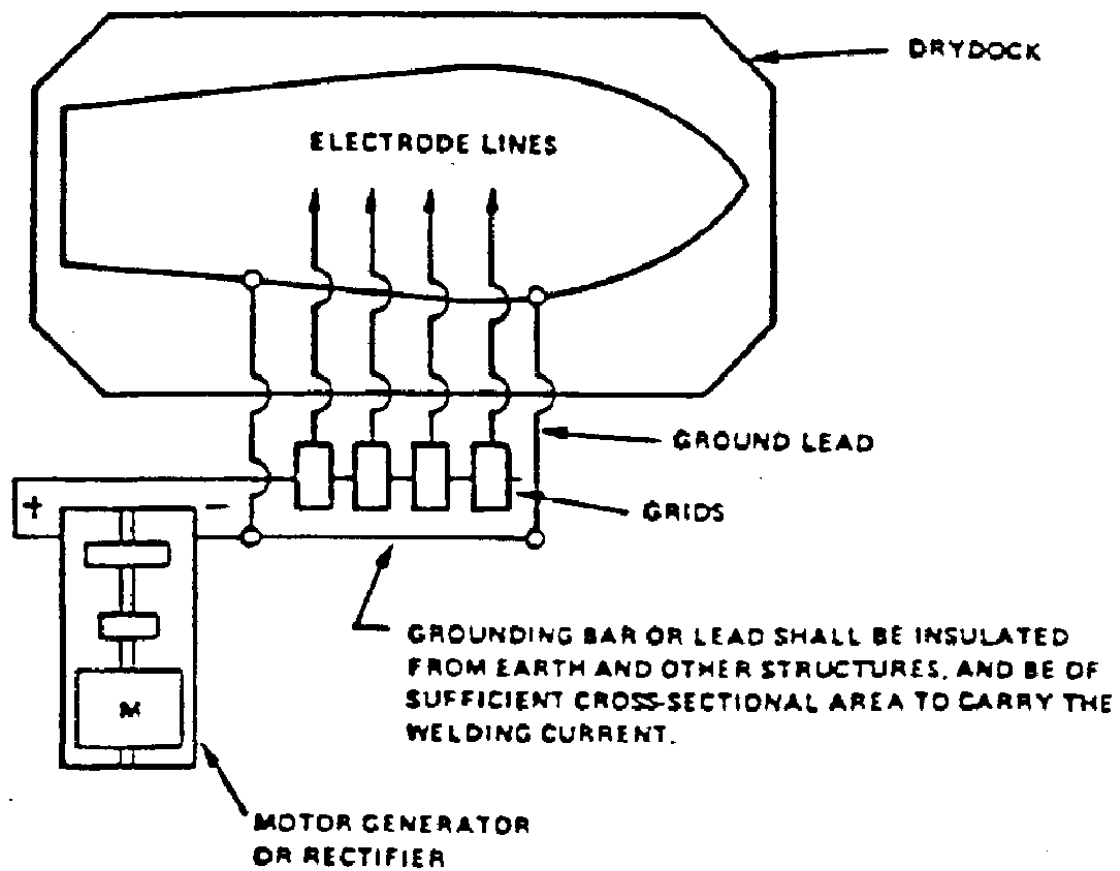


**LEGEND: M - MULTIPLE-OPERATOR SET
S - SINGLE-OPERATOR SET**

NOTE. WHEN THE GENERATOR OR RECTIFIER ON ONE SHIP GROUNDED TO THAT SHIP IS USED TO WELD ON ANOTHER SHIP WHICH IS WITHOUT A GROUND OR IS IMPROPERLY GROUNDED, ALL OR PART OF THE WELDING CURRENT RETURNS FROM SHIPS A AND B TO SHIP C THROUGH THE WATER.

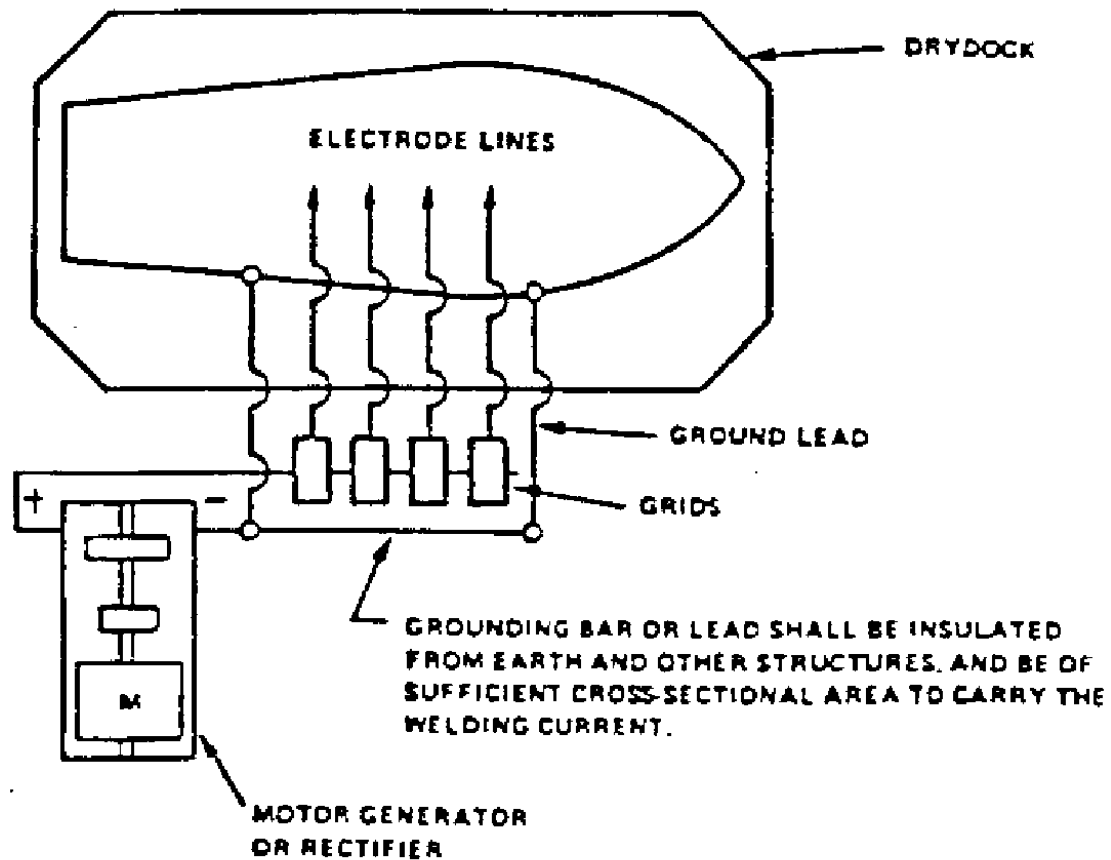
INCORRECT

Figure E-5. Hookup for Ships Afloat (Sheet 2 of 2)



LEGEND: M - MULTIPLE-OPERATOR SET

Figure E-6. Hookup for Ship in Floating Docks

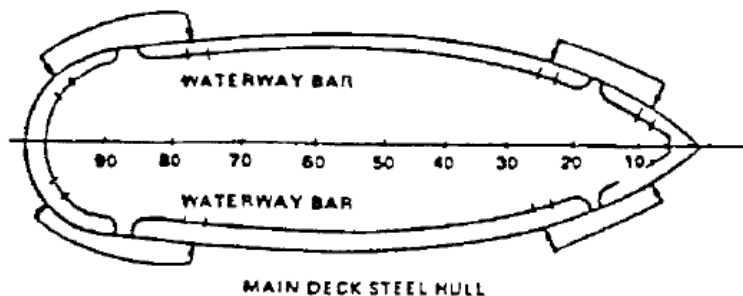


LEGEND: M = MULTIPLE-OPERATOR SET

Figure E-7. Hookup for Ships in Dry or Graving Dock

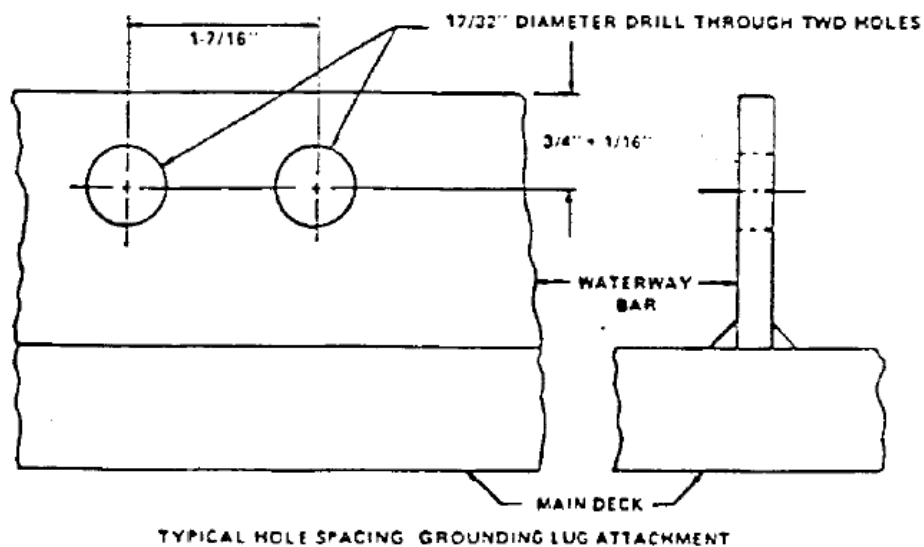
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NOTES:

1. LOCATE HOLES IN AREAS INDICATED BY ARROWS.
2. ON STEEL HULLS WITH NO WATERWAY BAR, DRILL HOLES IN DECK COAMINGS.
3. CLEAN LUG CONTACT AREA TO BARE METAL WHEN GROUNDING CONNECTIONS ARE MADE. (WHEN GROUNDS ARE BROKEN, THE AREA SHALL BE PAINTED TO MATCH THE SURROUNDING DECK.)
4. WITHIN 6 INCHES OF LUG CONTACT AREA, PAINT IN BLACK, 3/4-INCH-HIGH LETTERS: GROUNDING CONNECTION AREA.



NOTES:

1. HOLES ARE TO BE DRILLED AT LOCATIONS SHOWN ABOVE.
2. WHERE POSSIBLE, MODIFY AND UTILIZE EXISTING HOLES IN WATERWAY BARS.

Figure E-8. Return Current Connections on Steel Surface Ships